



Short Communication

Smoking environment cues reduce ability to resist smoking as measured by a delay to smoking task



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HIGHLIGHTS

- Smoking environments increase smoking urge and promote smoking behavior.
- Subjects initiated smoking sooner and smoked more after exposure to smoking cues.
- Greater craving associated with a shorter time to initiate smoking.
- Reduced craving after exposure to nonsmoking environments.
- Withdrawal associated with cigarettes smoked during smoking environment sessions.

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ABSTRACT

Introduction: Environments associated with smoking may promote lapse and relapse in smokers attempting to quit. Here we examined the effects of exposure to visual smoking environment cues on smoking urge and the ability to resist smoking, as measured with a delay-to-smoking task in which monetary contingencies are provided for resisting smoking. **Methods:** Adult daily smokers ($n = 22$) completed two experimental sessions, each following 6 h smoking abstinence. Sessions differed only in the type of cue participants were exposed to (smoking environments vs. nonsmoking environments). Participants completed subjective ratings of smoking urge, withdrawal and other reactions (i.e. craving, affect). Behavioral outcomes on the delay-to-smoking task included latency to first cigarette, number of cigarettes smoked and average number of puffs per cigarette. **Results:** Across cue exposure sessions, 64% of participants initiated smoking (no effect of condition was observed). However, exposure to smoking environments as compared to the nonsmoking environments resulted in greater craving, faster initiation of smoking, and more smoked cigarettes. Greater craving was associated with a shorter time to initiate smoking, but this effect did not differ across sessions. In contrast, withdrawal was more strongly associated with number of cigarettes smoked during smoking environment sessions. **Conclusion:** Together, these results suggest smoking environments increase smoking urge and promote smoking behavior. Further research is necessary to examine the specific and interactive effects of smoking-related environments on real-world smoking lapse and relapse.

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1. Introduction

Drug dependent individuals experience craving following exposure to cues associated with past or current drug taking (Carter & Tiffany, 1999; Conklin, 2006; Drummond, Tiffany, Glautier, & Remington,

1995; McClernon et al., 2016). Despite recognition of environments as influential determinants of drug use and relapse in animal models (Fuchs, Lasseter, Ramirez, & Xie, 2008; Marchant, Kaganovsky, Shaham, & Bossert, 2015), only limited research has specifically evaluated the effects of drug-environments on drug self-administration in humans. Conklin, Perkins, Robin, McClernon, and Salkeld (2010), Conklin, Robin, Perkins, Salkeld, & McClernon, 2008 found that pictures of smoking environments (e.g. park bench, bus stop) provoked craving at levels similar to proximal cues (e.g. lit cigarette). The current study seeks to extend this prior work by examining whether smoking

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environment cues decrease the ability of smokers to resist smoking. To test this, we used a well-validated analogue of smoking lapse, i.e. the delay to smoking task (DST).

The DST models smoking lapse and relapse by measuring how long a smoker can delay initiation of smoking in exchange for monetary reward while exposed to smoking paraphernalia (i.e. cigarette, ashtray, and lighter) (McKee et al., 2011; McKee, Weinberger, Shi, Tetrault, & Coppola, 2012). In this task, smokers are presented cigarettes and smoking paraphernalia and then instructed they can initiate smoking at any point, but will receive a monetary incentive for every five minutes they resist smoking. Latency to smoke and number of cigarettes smoked during the DST are associated with duration of nicotine abstinence and the magnitude of the monetary reinforcer (McKee et al., 2012). Here we examined how smoking environment cues (relative to nonsmoking environment cues) impacted DST outcomes. We hypothesized that exposure to smoking environments would decrease latency to first cigarette and increase ad lib smoking once smoking is initiated. We also examined the effects of smoking environment exposure on indices of smoking urge and other reactions (e.g. craving, affect) and whether craving or withdrawal predicted smoking behavior during the task.

2. Materials and methods

2.1. Participants

Twenty-two adult smokers were recruited. Participants were required to be ages 18 to 55, generally healthy (i.e. not currently ill, ambulatory), smoke at least 5 cigarettes per day (CPD) for ≥ 1 year, and have no interest in quitting smoking for the duration of the study. Participants were excluded if they used smokeless tobacco, or were currently abusing alcohol or other drugs (verified with breath and urine samples). All participants provided informed consent and all procedures were approved by the Duke University IRB.

2.2. Procedures and measures

Following a screening/training visit, participants completed two separate cue exposure sessions approximately one week apart following ≥ 6 h smoking abstinence (confirmed by a 40% reduction in breath carbon monoxide (CO) level from the value obtained at either the screening or training visits) (Conklin et al., 2010; McClernon et al., 2016). The two sessions differed only on the environmental cues presented (smoking or nonsmoking; order randomly assigned and counterbalanced). One session involved exposure to validated images (Conklin, 2006; Conklin et al., 2008; McClernon et al., 2016) of standard smoking environment cues (e.g. car, bus stop, restaurant, and bars); the other exposure to standard nonsmoking environment cues (e.g. gym, church, daycare, and auditorium). For each cue type (smoking, nonsmoking) cues consisted of 10 different environments, each presented from 4 different angles. Each session began with a 2 min cue exposure phase (see Fig. 1A), in which environment cues (smoking or nonsmoking images depending on session) were presented continuously for 2 min; for 3 s each. Afterwards, participants were shown 8 unlit cigarettes of their preferred brand and informed of the opportunity to initiate smoking at any time over a 60-min period. A monetary reinforcer (\$0.25) was provided for each 6-min period that a participant resisted smoking. Participants were allowed to read books or magazines. However, during the final minute of each 6 min period, a tone alerted them to view additional smoking or nonsmoking environment cues (four images shown for 15 s each). Each of the ten environments viewed during the cue reactivity phase were thus repeated during this phase. After the delay period ended (60 mins) or as soon as the participant decided to initiate smoking by pushing a button, they could then smoke ad lib for the next 30 min. During this phase, they were provided a \$4.00 smoking “tab” and for each cigarette they smoked, \$0.50 was deducted

from their tab. In cases where participants initiated smoking prior to the end of the delay period, environment cue presentation continued during the ad lib period until all cues were shown. This ensured all participants were exposed to the full set of cues regardless of when they initiated smoking. All participants were required to remain in the room for a full 90 min regardless of smoking behavior.

Participants completed the Minnesota Nicotine Withdrawal Scale (MNWS) upon arrival for each experimental session (Hughes & Hatsukami, 1986, 1998). Subjective ratings of positive affect (3 items), negative affect (1 item) and craving (4 items) were obtained before and after the cue-reactivity phase, as well as at the end of the delay period (i.e. either prior to lighting the first cigarette or the end of 60 min, whichever came first). Using an established scale (Conklin et al., 2010), participants rated their agreement with each statement (ranging from do not agree to strongly agree) using a 0–100 scale. Participants were video recorded during each session to assess smoking behavior (see below). Breath CO levels were measured at the beginning and end of each session to assess CO boost (post-pre) using a Vitalograph CO monitor (Vitalograph, Inc.; Lenexa, KS).

2.3. Data processing and analysis

Video recordings of behavior during the DST were coded by two independent raters in order to assess latency to first puff (in seconds), number of cigarettes smoked, and average number of puffs per cigarette. All analyses were conducted in SPSS Version 24.0 (IBM Corp., Armonk, NY) through application of a mixed models framework with a repeated statement and compound symmetry covariance matrix (analogous to repeated measures ANOVA/ANCOVA). First, we examined the effect of Environment Type (smoking vs. non-smoking) on craving and affective responses during the initial two-minute exposure period. Time (Pre-Exposure vs. Post-Exposure) was included as a factor and the Environment Type x Time interaction was of primary interest. Next, we examined the effect of Environment Type on smoking behavior during the DST (latency to first cigarette, number of cigarettes smoked). Lastly, we examined whether (A) Withdrawal (at arrival); (B) Cue-Induced Craving (post-exposure craving minus pre-exposure craving); and (C) Peak-Provoked Craving (craving immediately prior to entering the ad lib portion of the task) predicted smoking behavior. Each variable was introduced separately into a model with smoking behavior indices (latency to first cigarette, number of cigarettes smoked) as the dependent variable and both the main effect and its interaction with Environment were examined.

3. Results

3.1. Sample characteristics and coding reliability

Sample characteristics are presented in Table 1. CO levels were equivalent at the beginning of the smoking (mean = 7.05, SD = 4.1) and nonsmoking (mean = 7.05, SD = 5.1) cue sessions, $t_{21} = 0$, $p = 1$. Coding of smoking behavior videos by two raters was highly reliable across indices (ICC's 0.99–1.00). The average of the two coder ratings was used in analyses of smoking behavior.

3.2. Effects of environment type on craving and affect

During the initial two-minute exposure to environment cues, there were main effects of both Environment [$F(1.63) = 7.41$, $p = 0.008$] and Time [$F(1.63) = 16.89$, $p < 0.001$] on craving. However, these were qualified by a significant Environment x Time interaction [$F(1.63) = 6.70$, $p = 0.012$]. Post-hoc analyses indicated this effect was driven by a significant reduction in craving following presentation of nonsmoking environment cues [$F(1.21) = 19.31$, $p < 0.001$], with no change in craving occurring during presentation of smoking environment cues ($p = 0.247$). No other main effects or interactions for craving

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